Strategic Highway Research Program (SHRP) and the Measurment of Bitumen with the HAAKE Rheometers RS100 and RT10

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After 5 years of work, the 150 million US-Dollar project „Strategic Highway Research Program“ (SHRP) ended and a report of 30 0000 pages was presented. 50 million US-Dollars were used to determine the physical and chemical properties of bitumen and asphalt products. It was also necessary to develop new measurement methods to specify the behavior of the products under real conditions.
To determine the processing behavior of bitumen a simple viscosity measurement with a rotational viscometer at 135°C is necessary.

Using dynamic shear measurements (oscillation), it is possible to obtain information about the softness of the asphalt during application on the pavement; the recovery from deformation at increased temperatures; and wether fatigue cracks will occur at low temperatures.
The measurements should be performed with different kinds of binder. The test conditions are summed up in the table below.

[A] **Original binder**
[B] **Short time aged binder**: RTFOT-Test, Rolling Thin Film Oven Test
[C] **Long time aged binder** : PAV-Test, Pressure Aging Vessel

Test- conditions

Sample	Frequency	Temperature
[A]	10 rad/sec	46 - 82°C*
Plate/Gap	Deform.	
∅25mm/1mm	9-15%	
Sample	Frequency	Temperature
[B]	10 rad/sec	46 - 82°C*
Plate/Gap	Deform.	
∅25mm/1mm	8-12%	
Sample	Frequency	Temperature
[C]	10 rad/sec	4 - 40°C*
Plate/Gap	Deform.	
∅ 8mm/2mm	0.8-1,2%	

**The temperature depends on the highest or lowest expected temperature of the pavement.*
To classify the products we need to define two new values.

The value G*/sinδ classifies the deformation behavior of the product. The goal is to look for a high modulus together with a low phase shift angle. The value for sample [A] should be ≥1kPa and for [B] ≥2,2kPa.
The value G*•sinδ, (loss modulus) classifies the fatigue behavior of the sample. A low complex modulus together with a low phase shift angle should result in values ≤5000 kPa.

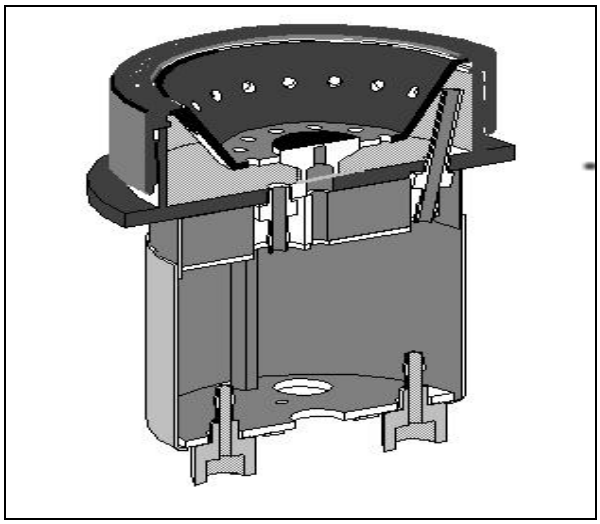

Fig.1: HAAKE SHRP Sensor

For accurate temperature control in the range from 4°C to 82°C, HAAKE developed a new temperature unit minimizing low temperature gradients across the diameter and through the gap. The sample is heated from all sides with a thermal liquid.
To avoid thermal loss, HAAKE supplies special rotors with a ceramic shaft. The temperature accuracy inside the sample is better than 0.1°C.

To classify different kinds of bitumen, it is necessary to test at several defined temperatures.
The frequency used is 10 rad/sec. The HAAKE software allows one to define a waiting time (e.g.5 cycles) and a number of repetitions (e.g 10 cycles). The repetitions are used to build an average value. The waiting time brings the sample to a stationary equilibrium state.

As an example, we can discuss the measurement of a bitumen in the temperature range from 4°C to 90°C. The oscillation measurement was done using the „autostrain mode“ with the proposed deformations. The result in Fig. 2 shows the dependence of the complex modulus and the phase shift angle on the temperature. The angle depends not very strongly on the temperature. The magnitude of the relationship between the storage modulus and the loss modulus does not very strongly.

With this example we can calculate the value G*/sinδ at different temperatures. The calculation is automatically done by the software using the option reference value. The software checks if the value ≥1kPa is fulfiled. The bitumen sample used shows up to a temperature of 82°C higher values. At 82°C we achieve a value of 1063,8Pa.
In this case the bitumen can be specified in the Performance Grade class 82, under the conditons that all other tests fulfil their respective criteria.
After the RTFOT-test the measurement at 82°C should give values of G*/sinδ above ≥2,2kPa.

The RTFOT-test sample has to go through the PAV conditioning for the next measurement. Then the sample has to be measured at 40°C, 37°C, 34°C, 31°C and 28°C.
The calculated value G*•sinδ should be below ≤5000 kPa. If the calculated result at 40°C fulfills the criteria, then the bitumen can be classified as Performance Grade PG82-10.

The bitumen can be used in the pavement temperature range 82°C to -10°C.

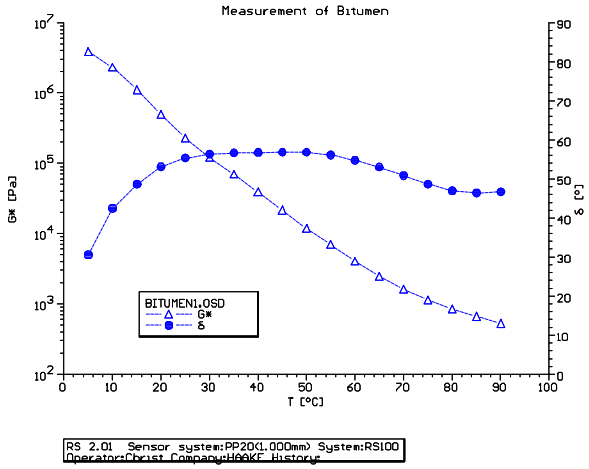

Fig.2: Temperature behavior of Bitumen

The above example shows that all measurements take time to classify the bitumen. The preparation of the sample, especially the RTOFT- and PAV-test (conditioning) and also the cleaning of the measurement system is time consuming.
The HAAKE Software reduces the time for the measurement itself to a minimum. The Job Stream allows a fully automatic measurement together with the evaluation in one step. In this case the user does not have to be a well-trained rheologist, because the „Job“ will perform the measurement and evaluation for the user.

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